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Preparation of Carbon Nanosphere From Bamboo And Its Use In Water Purification

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Abstract — Bamboo naturally acts as an antibacterial and antifungal agent and is capable of absorbing chlorine, bad odor and toxic substances from water as well as it also replaces with healthy minerals like sodium, potassium and iron transforming ordinary water into mineral water. In this paper, nanosphere was prepared by carbonizing pieces of bamboo in muffle furnace at 600°C under in-sufficient air. The black mass so obtained was functionalized with conc. nitric acid. It was then characterized by SEM, TEM, XRD, AFM etc. This was then treated with different metals to increase its absorption efficiencies. Considering the properties of bamboo, it was thought to develop an eco-friendly and cost effective water purification system using the nanospherical bamboo charcoal, requiring less efforts compared to other existing techniques. After doing the preliminary tests, it was found that this purification technique is able to remove arsenic and fluoride completely from the water.

Keyword — Carbon nanosphere, Bamboo, Carbonization, Filtration, Water purification

1. INTRODUCTION

Carbon nanomaterials such as carbon nanotubes, fullerenes, nanoflowers, nanodiamond, nanobricks and so many other forms of carbon nanostructures, have been developed intensively not only for their fundamental scientific interests but also for many technological applications [1]-[5]. One of the key factors in controlling the morphology and the yield of the carbon nanoparticles is the precursor material. In view of the depletion of petroleum resources, their negative environmental impacts, and increasing demand for carbon-based nanomaterials in various emerging fields, renewable carbon resources such as plant biomasses, plant extracts and hydrocarbons have been explored for the fabrication of carbon nanostructures [6]

Bamboo is naturally an antibacterial and antifungal agent and is capable of absorbing chlorine, bad odor and toxic substances from water. Moreover, it is abundant in nature, it has a carbon rich chemical structure so cost effective also. Since years, activated carbon is being extensively used as efficient and versatile adsorbents for purification of air, water and many chemicals and various natural products [7]. Although, making the modern technology accessible and affordable to the global poor is a very difficult task, but it is now well known that nanotechnologies offer more affordable, effective, efficient and durable ways to achieve this and also allow manufacturing process that is less polluting than traditional methods, requiring less labor, capital, land and energy [8]–[11]. In view of these facts, carbon nanosphere was prepared by pyrolyzing the pieces of bamboo in a muffle furnace at 600°C under in-sufficient air. The obtained charcoal was purified, functionalized and characterized by XRD, SEM. TEM, AFM, Raman, etc. Suitable non toxic metals were also incorporated in trace amounts to increase the absorption property of the functionalized charcoal. Based on some preliminary work on water purification, it was concluded that carbon nanosphere can be a suitable filter bed material for water filter system which will be economical and could be a complete tool for desalination and purification of water in the coming future.

2. EXPERIMENTAL

2.1 Materials

Bamboo has been arranged from the NIT Campus only, which was cutted into small pieces. Other chemicals, reagents and solvents were purchased from Merck.

2.2 Preparation and characterization of carbon nanosphere (CN) from Bamboo

Carbon nanosphere (CN) was prepared by carbonizing the pieces of bamboo at 600ºC in a muffle furnace under insufficient air. The black mass so obtained was then purified by solvent extraction using petroleum ether and acetone as solvents. The carbon powder was then functionalized by refluxing with dilute nitric acid. The acid was diluted with water and the black mass was allowed to settle while the supernatant liquid was decanted off. To remove nitrate completely this process was repeated several times. The obtained CN particles were further ball milled for 20 hrs, dried under vacuum and then characterized by SEM. TEM, AFM, powder X ray diffraction , Raman etc. which are shown in Figs.1-5.

2.3 Preparation of filter bed material and filter column

The ball milled carbon nanosphere from bamboo was used as such as filter bed for purification of water. For the removal of arsenic and fluoride, aluminium sulphate and ferric chloride (1:1 ratio and 10% by weight of CN) were further added to increase the adsorption property of the functionalized CN. Two sets of filter columns were prepared using two columns of 5.0 and 10.0 cm diameter, in order to check the rate of water collection per hour. The water containing chloride, arsenic and fluoride (as found in the ground water in north east zone), was passed through the columns and the collected water, was tested by usual methods.

3. Results And Discussion

It is well known that charcoal water filters are the best among all water filters in the market. Bamboo is beneficial to be used for purification of drinking and waste waters, where the content of metal ions often exceeds the admissible standards [12]. Besides, there is countless microorganism perches in the hole of the bamboo charcoal which not only can dehumidify, deodorize but also can suck harmful chemical materials. Fig.1 shows the SEM image of uniformly distributed spherical CN particles in the size range of 300-600 nm. The preparation of this broad range of particles size was done to further enhance the adsorption properties of the particles. It was observed that when the functionalized CN was subjected to ball milling for 20 hrs it formed uneven sized particles which increases the absorption properties.

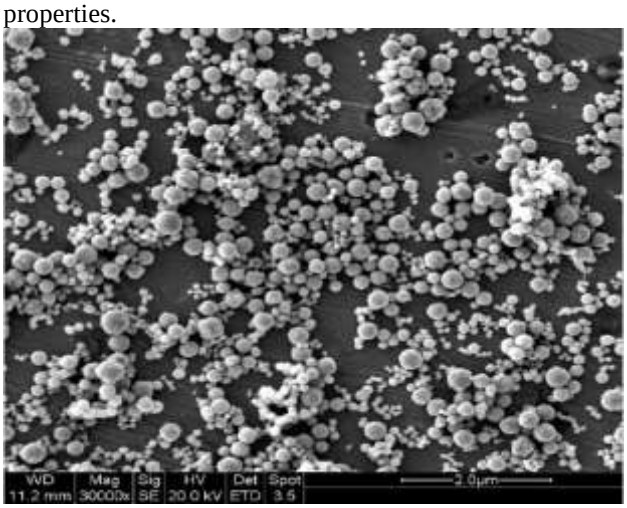

Fig.1: SEM image of Carbon nanosphere

Figs. 2, 3 show the TEM and AFM of nano sized CN particles respectively.

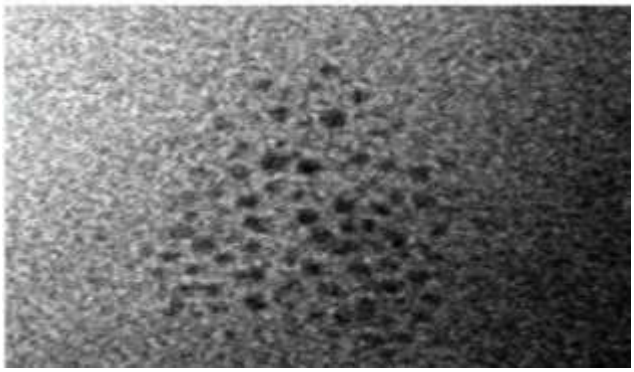

Fig.2: TEM image of Carbon nanosphere

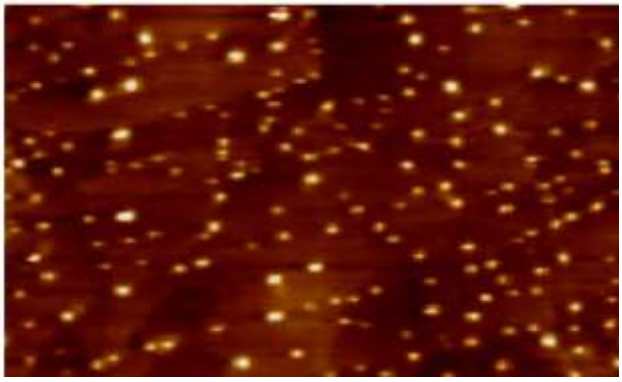

Fig.3: AFM image of Carbon nanosphere

XRD pattern of CN (Fig. 4) shows two intensed peak at 25^0 and 44^0 which were assigned for (002) & (001) reflections respectively and confirms the good extent of graphitization.

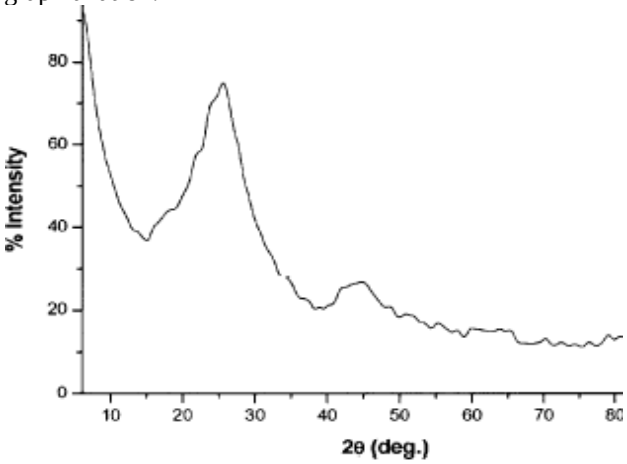

Fig.4: XRD image of Carbon nanosphere

Fig. 5 shows Raman shift at 1359 cm^{-1} and 1612 cm^{-1} respectively, which further confirmed the size of the CN particles in nano range.

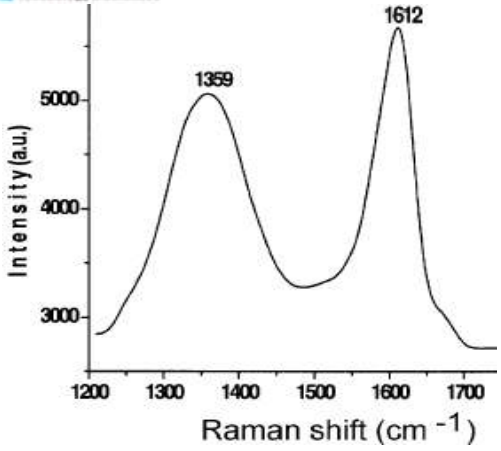

Fig.5: Raman image of Carbon nanosphere

When the water containing chloride, arsenic, fluoride was passed through different sized diameter columns, it removed 90% of the chloride from the water in a single run. It was important to observe that arsenic and fluoride removed completely in that single run. Thus it is clear that the porous nature of bamboo charcoal, its nanosperical size, combined with its activated carbon nature, was responsible to adsorb chloride as well as arsenic, fluoride and other heavy metal impurities from the water. Further, it was found that in the case of two sets of column of different diameter, maximum amount of water collected per hour takes place in the case of column with 10 cm diameter, irrespective of the thickness of the filter bed material (Table1).This further proved that the selection of CN as adsorbent for removal of metal ions from water, essentially depends on both the properties of the activated nature of CN particles as well as the nano-size of the CN particles.

4. CONCLUSION

Bamboo is known to be one of the most popular bioresources and its charcoal has an effective adsorbent properties for removal of humidity and odors. In this work, carbon nanosphere was prepared by pyrolyzing the bamboo pieces at 600ºC then ball milling of the coarse particles to smaller one, followed by consecutive treatment with acid. For desalination, this filter bed material was used as such but for efficient removal of arsenic and fluoride, 10% of a mixture of aluminium sulphate and ferric chloride, by weight of charcoal was added. It was found that this filter system removed 90% of chloride from water in a single run. It was highly interesting to observe that arsenic and fluoride were removed completely in that single run. When water was passed through different sized diameter columns, maximum amount of purified water was collected from the column with 10 cms diameter. In the present situation, when the availability of clean water supply across the world is decreasing, if this work in large scale, goes to plan, it could become a highly significant piece of technology from the economic point of view also.

Table-1: Study on the removal of arsenic, fluoride and chloride using different column size

Width of column (cm)	5.0			10.0		
Height of CN mixture (cm)	2	3	4	2	3	4
Height of water over the CN bed (cm)	30	30	30	30	30	30
Rate of flow (ml/h)	1060	1100	1100	7000	6990	7000
(%) of chloride in water after passing through the column	10	10	10	10	10	10
(%) of Fluoride in water after passing through the column	Nil	Nil	Nil	Nil	Nil	Nil
(%) of Arsenic in water after passing through the column	Nil	Nil	Nil	Nil	Nil	Nil

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